

array transducer, and further comprising a digital beamformer coupled to receive signals from said array transducer for producing digital beamformed harmonic signals.

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38. (Newly added) The ultrasonic diagnostic system of Claim 6, wherein said material comprises an ultrasonic contrast agent.

REMARKS

Claim 8 was rejected under 35 U.S.C. §112 on the basis that there is insufficient antecedent basis for the limitation "the decimation rate". Accordingly, Claim 8 has been amended to delete this limitation. It is therefore respectfully submitted that the §112 rejection of Claim 8 has been overcome.

Claims 1-36 were rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Pat. 5,456,257 (Johnson et al.) Certain of these claims have been amended to more clearly define the present invention.

Claim 1 describes an ultrasonic diagnostic system for the coherent detection of ultrasonic contrast agents. An ultrasonic probe receives ultrasonic echo signals following a pulse transmission and a beamformer forms coherent echo signals. Means are provided for differentiating and detecting coherent echo signals, and a display is provided for displaying detected differentiated signals emanating from the contrast agent. Johnson et al. do not differentiate or detect coherent echo signals. As Fig. 1 of Johnson et al. shows, the pulse-pulse differentiation circuit 24 follows the envelope detector 20. Thus, Johnson et al. do not have the advantage of sensitivity of an embodiment of Claim 1, as discussed on page 8 of the present specification.

Claim 2 recites the use of an amplitude detector for detecting differentiated coherent echo signals. Johnson et al. have an envelope detector before the pulse-pulse differentiation circuit.

Claim 5 recites that the display displays a B mode image combined with the display of detected differentiated contrast signals, which is not shown or suggested by Johnson et al.

For the foregoing reasons it is respectfully submitted that Claims 1-5 are patentable over Johnson et al.

Amended Claim 6 describes an ultrasonic diagnostic system for the detection of a harmonic response of material inside the body comprising an ultrasonic transducer probe for transmitting ultrasonic pulses at a first frequency into the body and receiving harmonic ultrasonic echo signals following



a pulse transmission. A receiver is provided for receiving harmonic signals emanating from material inside the body and a programmable filter filters the received harmonic signals with a passband excluding the first frequency and including a harmonic of the first frequency. A harmonic signal detector detects the received harmonic signals and a display is provided for displaying received harmonic signals. Johnson et al. use a filter 20 to remove noise and other extraneous signal components but do not have a filter to filter received harmonic signals as recited in amended Claim 6. Johnson et al. also do not show a harmonic signal detector or a display for displaying received harmonic signals. Claim 7 recites that the programmable filter is a programmable digital filter, which is not mentioned in Johnson et al. Claim 8 recites that the programmable characteristics of the digital filter include the weighting of received signals, and Claim 9 recites that the programmable filter comprises an FIR filter, none of which is described in Johnson et al. Amended Claims 10 and 11 describe the use of both a B mode processor and a harmonic signal detector, which is not suggested by Johnson et al. Amended Claim 12 describes a three dimensional image processor for rendering three dimensional images of received harmonic signals, which is not shown or suggested by Johnson et al. Newly added Claim 36 recites the further inclusion of a digital beamformer for producing beamformed digital harmonic signals, which is not suggested by Johnson et al. For these reasons it is respectfully submitted that Claim 6 and its dependent claims 7-12, 37 and 38 are patentable over Johnson et al.

Claim 13 describes a method for ultrasonically detecting the perfusion rate of tissue by ultrasonic contrast agents comprising the steps of introducing an ultrasonic contrast agent of microbubbles into the bloodstream, transmitting an ultrasonic pulse which destroys microbubbles in the tissue, and, following the destruction of microbubbles by a time interval, ultrasonically measuring the degree of microbubble reperfusion of the tissue during the time interval. This method is not shown or suggested in Johnson et al., which makes no mention of perfusion of tissue or suggests any technique for measuring tissue perfusion. Claim 14 adds the step of repeating measuring with a different time interval and Claim 15 repeats measuring with the same time interval. Claim 17 adds an ultrasonic image to the perfusion measurement. Claim 18 describes the use of pulses of different frequency and amplitude characteristics. Since none of these features are suggested by Johnson et al., it is

respectfully submitted that Claims 13-18 are patentable over Johnson et al.

Amended Claim 19 describes a method for ultrasonically imaging a region of the body which exhibits a nonlinear response to ultrasonic energy comprising the steps of transmitting a first pulse into the body which is focused at a first depth within the body to cause a nonlinear response from material located at the first depth, receiving echoes containing nonlinear response signal components following the transmission of the first pulse, transmitting a second pulse into the body which is focused at a second depth within the body to cause a nonlinear response from material located at the second depth, receiving echoes containing nonlinear response signal components following the transmission of the second pulse, and producing an ultrasonic image from nonlinear response signal components of echoes received following the first and second pulses. Johnson et al. do not show or suggest the use of different focal depths for different pulse transmissions. Claim 23 recites the use of third and fourth pulses for different focal depths which is also not shown or suggested by Johnson et al. Accordingly it is respectfully submitted that amended Claim 19 and its dependent Claims 20-23 are patentable over Johnson et al.

Claim 24 describes a method of ultrasonically imaging tissue whose perfusion has been enhanced with an ultrasonic contrast agent in the presence of a blood pool containing contrast agent comprising the steps of insonifying the perfused tissue and blood pool, receiving echoes returned from ultrasonic contrast agent in the perfused tissue and blood pool, processing the received echoes for display by displaying greater intensity echoes with a lesser brightness or color intensity than echoes of lesser intensity, whereby the perfused tissue is highlighted in the display relative to the blood pool. This method is contrary to the usual display of received echoes, which is to display greater intensity echoes with greater brightness or color than lesser intensity echoes. The claimed display technique enhances tissue perfusion in the presence of blood pools which would otherwise overwhelm the display of tissue perfusion. No such technique is shown or taught by Johnson et al. Accordingly it is respectfully submitted that Claim 24 is patentable over Johnson et al.

Claim 25 describes a method of ultrasonically detecting microbubble destruction events by using a transmitted wave exhibiting a range of frequencies including a frequency which is destructive of microbubbles of a different size. Such a method allows a user to target microbubbles for destruction by

use of a transmit frequency chosen in accordance with bubble size. No such technique is shown or suggested by Johnson et al. Accordingly it is respectfully submitted that Claim 25 is patentable over Johnson et al.

Claim 26 describes a method of ultrasonically detecting a microbubble contrast agent present in the body by high PRF pulses comprising the steps of transmitting a first ultrasonic pulse into the body which causes a first response from the microbubbles, receiving a desired microbubble response to the first ultrasonic pulse, transmitting a second ultrasonic pulse into the body which causes a second response from the microbubbles, receiving a desired microbubble response to the second ultrasonic pulse and an undesired echo response to the first ultrasonic pulse, processing the received microbubble responses by incoherent detection, whereby the desired and undesired responses exhibit opposite polarities, and eliminating the undesired response. Johnson et al. do not suggest the reception of desired and undesired echo responses, or the processing of desired and undesired responses with opposite polarities, or the elimination of undesired responses. Claim 27 adds the feature that the responses are the presence and absence of microbubble destruction. Claim 28 adds the characteristic of different depths for the different responses. None of these features are shown or suggested in Johnson et al. Accordingly it is respectfully submitted that Claims 26-29 are patentable over Johnson et al.

Claim 30 describes an ultrasonic diagnostic system for the detection and display of ultrasonic contrast agents within the body comprising an ultrasonic transducer probe for transmitting ultrasonic pulses into a body infused with an ultrasonic contrast agent and receiving ultrasonic echo signals following a pulse transmission, including means for transmitting high and low energy ultrasonic pulses, a trigger circuit responsive to a physiological function for triggering high energy ultrasonic pulse transmission, a contrast signal processor for processing echoes received in response to high energy pulse transmission, a B mode signal processor for processing echoes received in response to low energy pulse transmission, and a display for displaying simultaneous real time B mode images and triggered contrast agent images. Johnson et al. do not use high and low energy transmission pulses, nor a B mode signal processor for processing echoes from the low energy pulses. The periodic triggering of high energy pulses is also missing from Johnson et al. Claim 31 adds a frequency characteristic to the transmitted pulses which is also absent from Johnson et al. Accordingly it is

respectfully submitted that Claims 30-32 are patentable over Johnson et al.

Claim 33 describes an ultrasonic diagnostic system for the detection and display of ultrasonic contrast agents within the body comprising an ultrasonic transducer probe for transmitting ultrasonic pulses into a body infused with an ultrasonic contrast agent and receiving ultrasonic echo signals following a pulse transmission, including means for transmitting high and low energy ultrasonic pulses, a trigger circuit for periodically triggering high energy ultrasonic pulse transmission, a contrast signal processor for processing echoes received in response to high energy pulse transmission, a Doppler processor for processing Doppler echoes received by the transducer probe, a B mode signal processor for processing echoes received in response to low energy pulse transmission, and a display for displaying real time B mode images containing color Doppler image information and periodically containing contrast agent image information. Johnson et al. do not show or suggest the interactive use of B mode and Doppler processing described in Claim 33, nor the use of high and low energy pulses recited in the claim. Accordingly it is respectfully submitted that Claims 33-36 are patentable over Johnson et al.

In consideration of the foregoing amendments to the claims, two citations are included for the Examiner's review. They are U.S. Pat. 5,577,505 which purports to be able to detect second harmonic responses through the transmission of low and high power pulses. U.S. Pat. 5,410,516 describes a method which images and evaluates the Doppler spectrum of the harmonics of an excitation frequency of microbubbles. It is respectfully submitted that the claims as amended are patentable over these patents.

In view of the foregoing amendment and remarks it is respectfully submitted that Claim 8 is now clear and definite and that Claims 1-38 are patentable over Johnson et al. Accordingly it is respectfully requested that the rejection of Claim 8 under 35 U.S.C. §112 and of Claims 1-36 under §102(e) be withdrawn and that new Claims 37 and 38 be allowed.

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In light of the foregoing amendment and remarks, it is respectfully submitted that this application is now in condition for allowance. Favorable reconsideration is respectfully requested.

Respectfully submitted,
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